Atrial Transseptal Puncture Techniques

Atrial transseptal puncture is increasingly important for cardiac interventions and has undergone recent technical advances.

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The left atrium (LA) is the most difficult cardiac chamber to access. Using conventional catheters/guidewires, it can be reached only by the difficult and rarely used retrograde crossing of the mitral valve. In the 1960s, Ross, Braunwald, and Brockenbrough introduced the atrial transseptal puncture technique to enter the LA from the right atrium (RA).[1-3] They demonstrated that the right femoral vein and inferior vena cava (IVC) were large enough, straight enough, and flexible enough to accept passage of a long needle even when it had a distal curve sufficient to turn toward the atrial septum.

Prior to this development, LA pressures had been measured by advancing a straight needle down through the left main bronchus at bronchoscopy, via a forward paravertebral puncture, or with a needle advanced down and forward from the suprasternal notch, called the Radner technique.[4] Although the Radner technique meant that the needle could traverse the pulmonary artery or aorta on its way to the LA, it had a very good safety record.[5] These methods illustrated that the walls of the cardiac chambers and great vessels could tolerate passage of a very thin sterile needle. This safety feature was incorporated into the transseptal equipment when the original formidable Ross needle was modified to have the distal 1.5 cm of the needle of smaller caliber (Figure 1). The needle has at its hub a direction arrow that corresponds to the needle curve, necessary when viewing the needle on two-dimensional

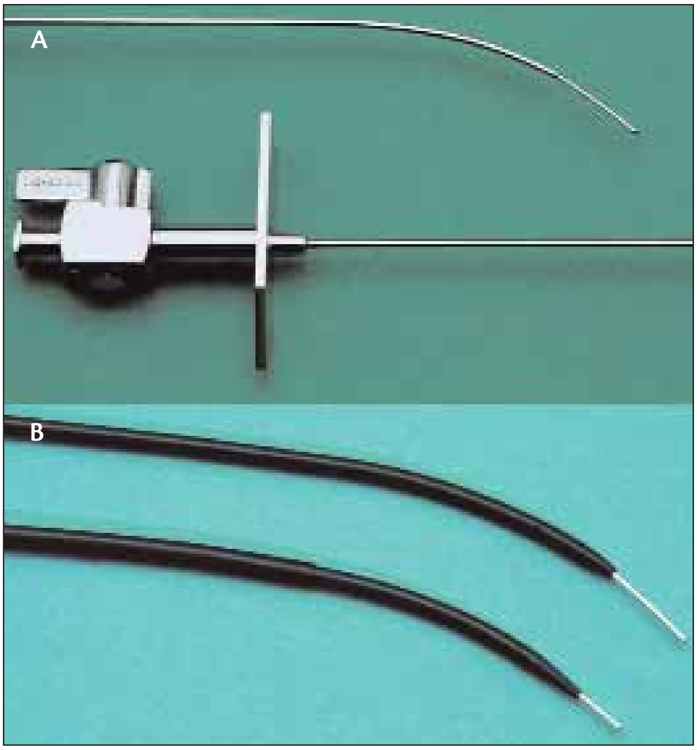

Figure 1. Distal and proximal ends of the Brockenbrough needle (A). The Brockenbrough needle within the Brockenbrough catheter (top) and the Mullins catheter (bottom) (B).

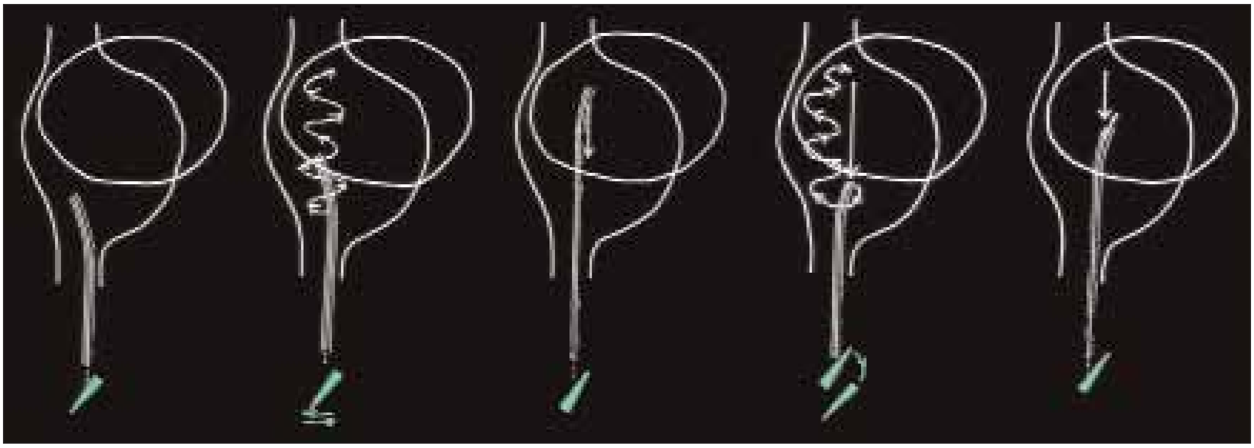

Figure 2. The anterior staircase maneuver.

fluoroscopy. The Brockenbrough catheter allows the distal 1.5 cm of the needle to protrude beyond its tip. It has distal side holes for contrast injection. The Brockenbrough needle can also be used with the Mullins catheter, which has a more tapered tip without side holes (Figure 1). It allows the distal 1 cm of the needle to protrude.

CLASSIC TECHNIQUE

A guidewire (.035-inch for the Brockenbrough catheter and .032-inch for the Mullins catheter) is passed via the right femoral vein to the superior vena cava using the anteroposterior fluoroscopy view. The catheter is advanced over the wire, and the wire is then withdrawn. The curved needle is then allowed to make its own twists and turns as it is moved up until its tip is just within the end of the catheter. With modern fluoroscopy, this can be appreciated visually; previously, a marker suture was tied around the needle hub at the position found in vitro to correspond with this needle position. The direction arrow is rotated to face posteriorly to 4 o'clock, as viewed from below, if the LA is of normal size, or to 5 or 6 o'clock for a moderately enlarged or very large LA. The catheter and needle are withdrawn together until they are seen to slip medially on entering the RA. They continue to be slowly withdrawn until a small jump of the catheter/needle is seen and/or felt as the tip drops over the limbic edge into the foramen ovale. The assembly is advanced slightly upward to confirm that it is catching on the atrial septal wall. With the catheter held immobile, the needle is advanced forward. Often, a "give" sensation can be felt by the operator as the needle crosses the septum. Not infrequently, when a patent foramen ovale is present, both the catheter and needle jump forward together into the LA when the initial upward pressure is applied.

During and after the needle has been advanced beyond the catheter, it is vital to keep the catheter immobile with the left hand until it has been confirmed that the needle is indeed within the LA. This is confirmed by using at least two of the following maneuvers through the needle: (1) aspiration of oxygenated blood, (2) recording an LA pressure, or (3) a contrast injection is seen to swirl within the LA cavity.

Once confirmation of LA entry has been obtained, both the catheter and needle are advanced together. As soon as the catheter is in the LA cavity, the direction arrow is rotated to 3 o'clock to avoid impinging on the posterior LA wall. If the LA is small, added protection from posterior wall damage can be given by advancing a .014-inch angioplasty guidewire through the needle.

If entry into the LA is not confirmed, the needle and the catheter must be drawn back prior to seeking an alternative septal position. The catheter can be repositioned into the superior vena cava again over a guidewire, and the process of withdrawal down the atrial septum is repeated this time to find a nearby but alternative point to catch on the atrial septum. Alternatively, when the catheter reaches the lower part of the right atrium, the "anterior staircase" maneuver can be used (Figure 2).[6] The direction arrow is rotated to 12 o'clock so that the needle curve points anteriorly. The IVC enters at the back of the RA, and there is adequate space within the RA cavity to accommodate the curve. The catheter/needle is advanced to the top of the RA while continuously moving the direction arrow between 2 and 10 o'clock to check that there is no impingement on the RA wall. The catheter/needle is then rotated to 4 to 6 o'clock, and the movement down the atrial septum is repeated. This maneuver avoids multiple changes between the guidewire and needle when a difficult case requires multiple passes down the septum.

It is crucial to ensure that only the needle and not the catheter is advanced until LA entry is confirmed. The needle can be safely removed even from the aorta or pericardium, but if the much larger catheter has been advanced to these positions, the patient must be sent to cardiac surgery for safe removal.

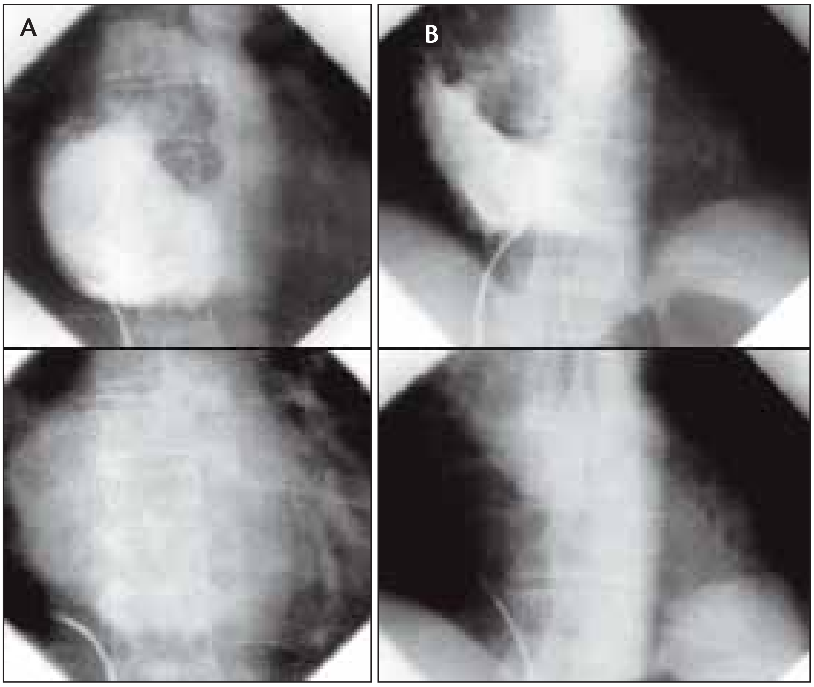

Figure 3. Contrast injection into the RA with follow through to the LA. The patient had mitral stenosis and an enlarged RA and LA (A). Very distorted anatomy in a different patient with aortic stenosis and an intrapericardial cyst (B).

THE VISUAL TARGET

If no drop across the limbic edge is observed, which is not uncommon with dilated atria, then a visual target must be used. In the anteroposterior fluoroscopy position, the lower border of the LA is visible when the LA is enlarged, and the upper border can be estimated from the bifurcation of the trachea. The crossing point will usually be approximately two thirds of the way down the vertical height of the LA. Hung proposed aiming for a position at the height of one vertebral body from the lower edge of the LA.[7] This takes into account the need to seek a lower position when the LA is very enlarged. Inoue introduced injecting contrast into the RA and maintaining acquire-mode fluoroscopy until the LA cavity is outlined.[7] The area of RA/LA overlap can then be memorized in relation to the vertebral bodies and used as a visual target. This is particularly helpful if there is distorted anatomy (Figure 3).

If immediate crossing is not obtained, some cardiologists inject a small volume of contrast through the needle to confirm that this causes staining within the atrial septum. Experienced operators can use this method to judge if the needle is too high in the septum or the needle tip is caught within a thickened septum.[7]

ALTERNATIVE FLUOROSCOPIC POSITIONS

Electrophysiologists, who usually deal with normally sized LAs, use the left anterior oblique position because it better profiles the drop of the catheter over the limbic edge. Some operators prefer the right anterior oblique (which has the atria enface), or lateral position, employing a pigtail catheter at the aortic valve (to mark the upper end of the tricuspid valve) and the inferior cardiac border as landmarks. Some operators like to move briefly to the lateral position to confirm that the needle curve is pointing posteriorly.

ADDITIONAL VISUALIZATION WITH ULTRASOUND

Transthoracic echo has also been used to check the needle position.[8] However, if time-consuming additional imaging is undertaken, there is the risk that the stainless steel needle can induce thrombus within the catheter.

The advent of new interventional procedures, such as mitral valve repair, has created a need to achieve a target-specific (usually higher) atrial crossing point to help instruments cross the mitral valve. This has led to the use of intracardiac echocardiography (ICE) and transesophageal echocardiography; the latter is less expensive than ICE but requires sedation to guide transseptal crossing.[9,10] The role of ICE is still emerging. For ablation procedures, ICE can give additional information on ablation position and complications. These echo techniques may be helpful to new operators while they gain confidence in fluoroscopic guidance or in cases with distorted anatomy to confirm that the needle is pressing on the septum.

At EuroPCR 2007, Dr. Peter Block presented preliminary information on a new infrared intravascular imaging technique (SiteSeekir Trans-Blood Vision, CardioOptics, Inc., Boulder, CO), which uses a wavelength corresponding to the diameter of red blood cells. A similar approach allows satellites to image through clouds. At present, this technology is designed to enable visualization of the coronary sinus ostium but may allow direct use of visualization of the foramen ovale.

Recording an electrocardiogram trace via the Brockenbrough needle has also been used to guide identification of the foramen ovale.[11]

ALTERNATIVE ROUTES TO THE RA

The left femoral vein can also be used, and once the RA has been reached, the fluoroscopic appearances are similar. However tension on the abdominal veins created by the stiff needle/catheter can cause pain, requiring morphine.

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There are several reports that IVC filters can be safely crossed using catheters. If the IVC is occluded, pediatric cardiologists have experience of reaching the RA via percutaneous entry to a hepatic vein. Atrial septal puncture has also been carried out from the right internal jugular vein.[12] A new transseptal equipment set is being developed specifically for this route.

A NEW ALTERNATIVE TO NEEDLE PUNCTURE

A radiofrequency (RF) ablation system has been designed to create an atrial septal crossing point.[13,14] A stiff dilator sheath with a distal curve similar to the Brockenbrough needle delivers a flexible RF catheter (with side holes near its tip to measure pressure and inject contrast) toward the foramen ovale. When coaxial alignment of the RF catheter tip and close contact with the septum is achieved, 2-second bursts of RF energy create a hole through which the catheter tip advances. Puncture does not involve mechanical force, and this technique should avoid the problem of needle-resistant hard septa and the "overshoot" when a needle is forced through a tough septum, risking LA wall damage if the LA is small. It may also avoid the pain created by needle pressure in the occasional patient with a sensitive septum. To date, it has been used in conjunction with invasive echocardiography but this may not be necessary when operator experience increases. The RF catheter's distal end is more flexible than a needle, which may be helpful when there is a need to select a specific crossing site within the atrial septum. RF puncture has been shown to create a pattern of atrial septal injury similar to that of needle puncture.[15] However, it has not yet established if it has the same safety profile as a needle when cardiac wall perforation occurs.

TECHNICAL DIFFICULTIES

- Occasionally, pressure on the atrial septum causes pain, requiring opiate analgesia or, rarely, a general anesthetic.
- Some patients have a very tough septum that resists needle puncture. Usually, this can be overcome by applying even greater pressure to the septum, but in some cases, an alternative crossing point has to be sought. If the needle crosses but the septum resists passage of the catheter, this may be overcome by change from a Brockenbrough catheter to the more tapered Mullins catheter or by moving to the smaller-diameter pediatric Mullins/needle. Balloon dilatation of the septum over a guidewire can be used.
- Very high LA pressure can cause the atrial septum to bulge markedly into the RA cavity, displacing the catheter/needle as it descends the septum. Marked torque on the needle may be required to find a suitable crossing point.
- Giant LA: Very markedly enlarged LAs can, paradoxically, be difficult targets. A very low position may be needed.
- Aneurysms of the atrial septum appear formidable on echocardiography but are surprisingly easy to cross, in part because of a high incidence of associated patent foramen ovale.[16]

COMPLICATIONS

Larger series from single centers confirm that transseptal puncture is a very safe technique in experienced hands with an expected 99% success rate. However, a number of complications, some life threatening, can occur and must be anticipated.

Hemopericardium

Damage to the atrial free walls can cause hemopericardium. Every cardiac laboratory undertaking transseptal puncture should have an echo machine running or have rapid access to an immediate-startup echo device. The hemopericardium may remain small and contained, and the patient is simply closely monitored. If the accumulation of blood in the pericardium progresses and causes tamponade, immediate echo-guided pericardial aspiration is required, and blood can be autotransfused back to the patient. If the situation is not stabilized, referral for emergency thoracic surgery is required. In the early years of transseptal puncture, Braunwald reported tamponade developed in 21 of 1,765 patients who had transseptal puncture.[17] Two required surgery, two died, and the rest responded to medical treatment.

Vasovagal Reaction

An intense and resistant vasovagal reaction can result from pressure on the septum or by mediastinal bruising.[18] Echo is essential to differentiate this from hemopericardium. If the catheter has already entered the LA, it should not be immediately withdrawn. It may have crossed a cleft at the inferior RA/LA borders, which requires surgical removal to avoid massive hemorrhage.

Puncture of the Aorta

If only the needle tip has entered the aorta, it may be withdrawn. If the catheter has entered the aorta, referral to surgery is required.

Atrial Arrhythmias

The presence of the catheter/needle in the RA or LA can precipitate an atrial tachyarrhythmia. Usually, these are self-terminating and seldom require intravenous drug therapy.

Embolism

Standard meticulous care is needed to avoid air entering the catheter or needle. The stainless steel needle is thrombogenic, it should be removed, and the catheter should be flushed if there is any delay in achieving successful puncture. Heparin is given only after successful puncture because of the small risk of hemopericardium.

CONTRAINDICATIONS TO TRANSSEPTAL PUNCTURE

The only absolute contraindication to atrial transseptal puncture is thrombus at the atrial septum. Relative contraindications are thrombus elsewhere within the LA cavity, ongoing treatment with warfarin, or marked cardiac or thoracic deformity. Patch repair of the atrial septum, previously thought to be a contraindication, has now been shown to tolerate puncture well.[19] Patients with resistant pulmonary edema have had successful transatrial interventions when lying at 30°. Advanced pregnancy does not preclude passage of the catheter/needle through the abdomen.

CONCLUSION

Atrial transseptal puncture, almost eliminated by new imaging techniques, has undergone a major revival for electrophysiology ablations and new cardiac interventions. After many years of static standard technique, atrial transseptal puncture has seen a blossoming of technical variations, adjuvant imaging, as well as new equipment and their roles will become evident in the coming years. ■

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